SECTION 3

# Projections of Drainage Need

## 3.1 Introduction

Providing drainage service to the SLU involves draining and collecting excess water from irrigated lands, and conveying that drainwater to a point (or points) of disposal. The disposal options being considered, at least initially, include:

- Delta discharge
- Ocean discharge
- Deep well injection
- Landfill

Various treatment options could be used to reduce the drainwater volume or to reduce loads of toxic or problematic constituents making disposal more feasible or cost-effective. Regardless of the combinations of treatment and disposal considered, it is necessary to estimate the "raw" (or unimpaired) drainwater volume and quality that would be discharged if drainage service were provided.

This section presents initial estimates of drainwater volumes and quality to support development of preliminary drainage service alternatives. Separate estimates were made for WWD and the Northern SLU Districts, given the different conditions that exist in the two areas.

The general approach to quantifying drainwater volumes involves determination of the following parameters:

- Drainage service area
- Drained area (acreage within the drainage service area that would actually have tile drains installed)
- Drainage rate or average flow of drainwater discharged from the drained area

The product of the drained area and drainage rate represents the estimated drainwater volume. Characterization of drainwater quality then makes possible estimates of the total loads of dissolved salts and other constituents contained in the drainwater.

The drainage volume and quality estimates provided in this section are for purposes of developing preliminary drainage service options and alternatives. They are primarily based on earlier work, including the SJVDP (1990) and the SLUDP (Reclamation, 1991). The numbers in this section should be viewed as order-of-magnitude estimates, and will be used to characterize the potential range of costs and conditions in this report. They are not intended to represent a careful, new analysis of drainage conditions. Complete and detailed estimates of drainage conditions will be made for the alternatives development and impact analysis efforts that follow this Report.

## 3.2 Drainage Service Area

The SLU includes 713,000 acres — approximately 603,000 acres in WWD and 110,000 acres in the Northern SLU Districts. Various estimates have been made of the portion of these lands that currently require, or ultimately will require, drainage service. For these initial estimates, the drainage service identified in the *Special Report on Drainage and Water Service, Draft Supplement to Final Environmental Impact Statement* (Interior, 1984) have been used. That report identified 293,000 acres in the SLU that needed drainage service in 1983, or would require drainage service by 2095. More than three-quarters of this area (225,000 acres) falls within WWD, with the remaining 68,000 acres within the Northern SLU Districts.

## 3.3 Westlands Water District

### 3.3.1 Background

By 1984, landowners had constructed buried tile drainage systems on approximately 5,000 acres of land in WWD within a 42,000-acre area in which a collector system had been installed. Drainwater was being collected in open-joint pipe systems, and discharged to Kesterson Reservoir (for evaporative disposal) via the completed reaches of the Drain. Discharges into the Drain averaged 7,000 acre-feet annually from 1981 through 1984. Salinity of the drainwater (measured as TDS) averaged 10,000 parts per million (ppm), with selenium and boron concentrations averaging 366 parts per billion (ppb) and 12.6 ppm, respectively. When Kesterson Reservoir was closed in 1986, the collector pipes and most on-farm tile systems were deactivated.

### 3.3.2 Approach

Planning efforts conducted between 1989 and 1991 for the SLUDP (henceforth referred to as the "SLUDP analysis") included development of projections of drained area and drainwater quantity and quality. Alternative 1 included projections based on existing efficient irrigation practices. Those projections have been reviewed, leading to the conclusion that the SLUDP analysis remains valid in the context of current planning activities, and provides the best available basis for developing initial drainwater quantity and quality estimates for WWD. The SLUDP analysis is summarized here, along with discussion of conditions that are different from those previously assumed.

#### 3.3.2.1 Drained Area

Economic and hydrologic models were used in the SLUDP analysis to predict the rate at which farmers would install tile drain systems. Hydrologic modeling tracked shallow water table depths and root zone salinity, while economic modeling determined whether the benefits of drainage, in terms of increased production, exceeded drainage costs. The key assumption used for Alternative 1 at that time was that growers would bear the on-farm costs of drainage, but not any off-farm costs related to drainwater collection and disposal. In that way, model projections of drainage water production were based on physical characteristics affecting crop production and were not constrained by collection and disposal costs. That assumption serves as a reasonable premise, at least initially, for current planning efforts.

The SLUDP analysis indicated that installation of drainage systems would be initially rapid, reaching 46,000 acres in 5 years and 97,000 acres in 10 years, and would then moderate, reaching 137,000 acres in 20 years. The ultimate drained area was predicted to be 178,000 acres, reached at year 36 in the 50-year simulation, representing an average annual tile drain installation rate of nearly 5,000 acres.

Ten years have passed since the 1991 estimates were made. Drainage conditions have worsened and the extent of land needing drains installed has potentially increased. WWD has indicated in legal proceedings that a drained area of 200,000 acres would be acceptable. Given the uncertainty in the extent of drainage need, this Report assumes that 225,000 acres of drains will be installed, consistent with earlier estimates made in the Special Report (Interior, 1984).

#### 3.3.2.2 Estimation of Drainage Rates

In the SLUDP analysis, drainage rates were also a product of hydrologic and economic modeling, reflecting a wide array of then-current conditions, including: WWD's water supply, drainage system installation costs, irrigation system and management costs, energy rates and related groundwater pumping costs, farm production costs, and yields and prices. For Alternative 1, drainage fees, which could have been included to cover off-farm drainage costs, were assumed to be zero. The average drainage rate over the 50-year simulation was estimated to be about 0.3 acre-foot per acre.

Many of the factors noted above that influence drainage rate have changed, making it difficult to directly apply the results of the SLUDP analysis. Given this uncertainty, a range in the average drainage rate was assumed for purposes of bracketing the total drainwater volume that would be expected under present conditions (again assuming that drainage service is paid for through a water charge or other mechanism not directly related to the drainage volume per acre).

Drawing on the original work, an average rate of 0.3 acre-foot per acre was used to represent conditions with highly efficient on-farm irrigation systems and aggressive management. In conceptual terms, this is associated with the limits of "best available technology," not necessarily constrained by economic viability. Thus, this rate brackets the expected drainage volume on the low end.

A higher drainage rate of 0.5 acre-foot per acre was used to bracket the upper end of the range. Conceptually, this rate is intended to represent traditional drainage system design capacity. Thus, the range of drainwater volumes formed by these limits is correlated with conditions falling between existing and best available on-farm technology.

#### 3.3.2.3 Drainwater Quality

A hydrosalinity model developed at the University of California, Davis, was used to predict the quality of drainage water in the SLUDP analysis. It used data from the previously described hydrology and economics models, notably, applied water depth and quality as well as precipitation and crop evapotranspiration. It also simulated the processes of dissolution (leaching) and precipitation for three typical 6-foot root zones. Initial soil salinity conditions for the three typical root zones were derived from reported ranges in shallow groundwater salinity, using a number of assumptions regarding soil properties. The rates of leaching indicated by the SLUDP analysis, expressed in tons of dissolved solids per acre, were considered to be directly applicable to current conditions.

Initial selenium and boron levels were also based on shallow groundwater conditions as described in the Rainbow Report (SJVDP, 1990) and the 1991 SLUDP Draft EIS and Plan Formulation Appendix (Reclamation, 1991). For purposes of this analysis, both constituents are assumed to follow the same trend over time as TDS — a period of soil reclamation, with concentrations approaching a steady and lower level after many years.

### 3.3.2.4 Drainage Zones

The potential drained area in WWD extends along the entire eastern third of the district, covering a total of 225,000 acres. For purposes of planning and estimating drainage service costs, this large area was divided into three geographic zones. These are shown in Figure 3-1. Zone A of WWD extends from the northern boundary of the district to the southeast, to the narrow area of shallow groundwater south of Tranquility. It includes a large portion of lands with high salt levels and shallow groundwater, and includes all of the area with selenium exceeding over 200 ppb. Zone B extends from this boundary, southeast, to a boundary defined at the terminus of the existing Drain. Zone C is southeast of that boundary.

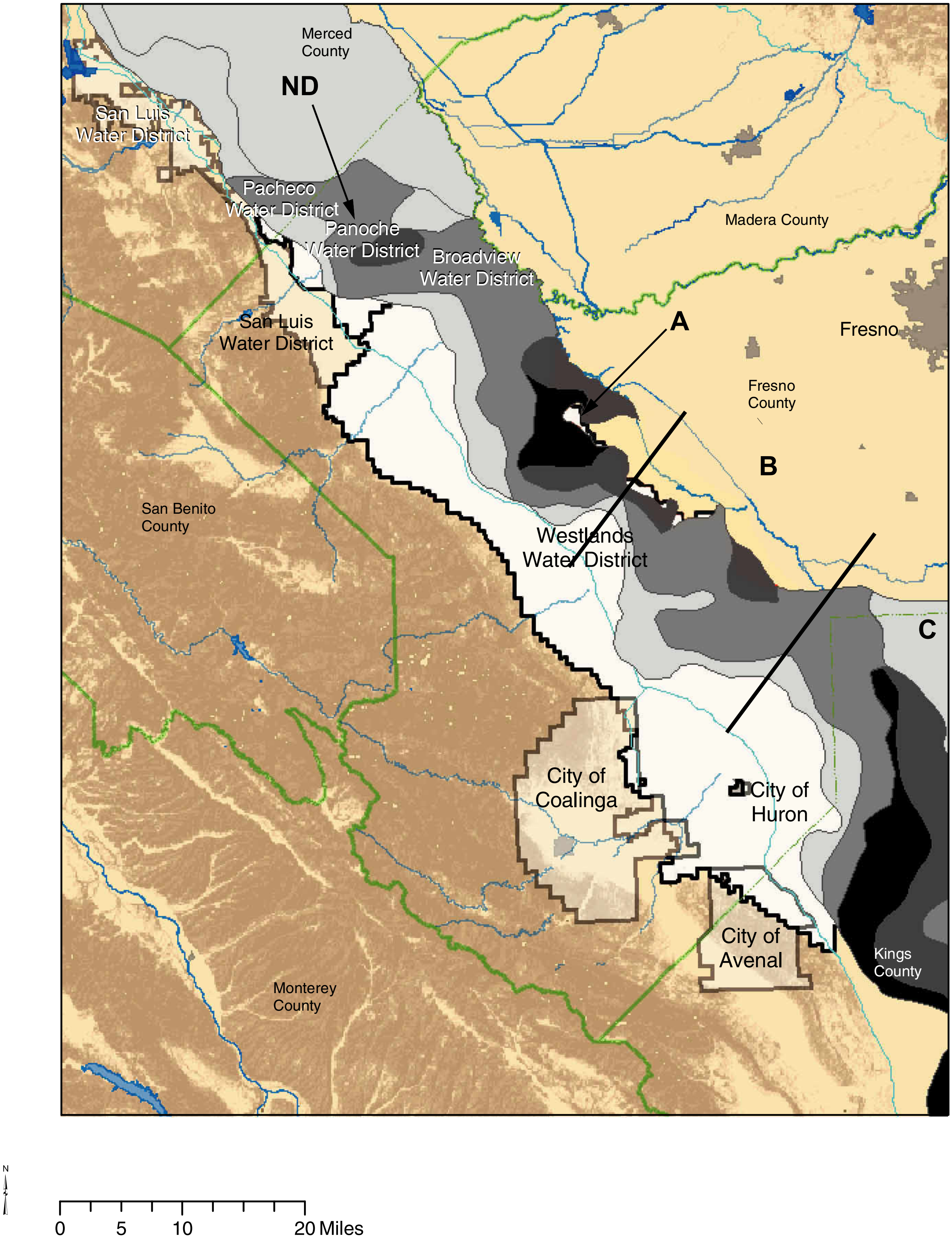
The original salt load projections in the 1991 SLUDP Plan Formulation Appendix (Reclamation, 1991) were aggregated for the entire drained area of WWD. In order to split these into the three zones, we have used a simple and rough allocation of drained land, drainage volume, and constituent load. Table 3-1 summarizes the allocation mechanism assumptions and starting values. Assumptions were designed so that total salt loads from the three zones equaled the 1991 totals (after adjustment for drained area, as discussed previously).

**TABLE 3-1**
Assumptions for WWD Drainage Zones

| WWD Zone | Percent of Drained Area | Percent of Total Salt Load | Starting Se Concentration (mg/l) | Starting B Concentration (mg/l) |
|---|---|---|---|---|
| A | 33.3% | 45% | 0.366 | 12.6 |
| B | 33.3% | 25% | 0.125 | 12.6 |
| C | 33.3% | 30% | 0.050 | 12.6 |

Se selenium
B boron
mg/l milligrams per liter

**Figure 3-1.** Zones Used for Drainage Projections

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## 3.4 Results

Table 3-2 summarizes the results of the updated analysis. Appendix A includes more complete data. The estimates cover a 50-year period expressed in relative terms. Year 1 represents the first year in which installation of tile drains would be allowed. As previously noted, tile drain installation would be rapid at first and would then moderate, reaching an ultimate area of 225,000 acres by Year 36. Drainwater volumes would follow similar patterns, reaching ultimate levels of 67,500 acre-feet under the assumed drainage rate of 0.3 acre-foot per acre, and 112,500 acre-feet under the higher rate of 0.5 acre-foot per acre. Unit mass loads of salt, selenium, and boron, expressed in tons per drained acre, would be high initially and would gradually diminish as soils are reclaimed.

For these initial estimates, it was assumed that constituent mass loads would be the same for both drainage rates. Thus, for the lower drainage rate in Zone A, drainwater salinity would reach an equilibrium value of 4,860 ppm TDS; for the higher rate, salinity would reach a proportionately reduced concentration of 2,916 ppm TDS.

## 3.5 Northern SLU Districts

### 3.5.1 Background

The four Northern SLU Districts (Broadview, Panoche, Pacheco, and portions of San Luis) contain more than 61,000 irrigated acres, of which 35,600 acres were actively draining through subsurface tile drains (Reclamation, 1991). Conditions in the Northern SLU Districts draining to the San Joaquin River have changed since the 1991 SLUDP. For the past few years, the districts have been restricted in the selenium load they are allowed to discharge to the river. As a result, programs of recycling and planned discharge have been used by each district to meet its allocated discharge load.

### 3.5.2 Approach

#### 3.5.2.1 Drained Area

It is assumed for this report that the existing drained acreage is sufficient to achieve drainage service to the Northern SLU Districts. Therefore, the 35,600 drained acres reported in the 1991 SLUDP are maintained throughout the 50-year period of projection.

#### 3.5.2.2 Estimation of Drainage Rates

As was described previously, conditions that affect drainage rates have changed since the 1991 SLUDP study, making it difficult to directly apply the results of that analysis. Given this uncertainty, a range in the average drainage rate was assumed for purposes of bracketing the total drainwater volume that would be expected under present conditions (again assuming that drainage service is paid for through a water charge or other mechanism not directly related to the drainage volume per acre).

An average drainage rate of 0.3 acre-foot per drained acre was used to represent conditions with highly efficient on-farm irrigation systems and aggressive management. In conceptual terms, this is associated with the limits of “best available technology,” not necessarily constrained by economic viability. Thus, this rate brackets the expected drainage volume on the low end.

A higher drainage rate of 0.5 acre-foot per acre was used to bracket the upper end of the range. Conceptually, this rate is intended to represent traditional drainage system design capacity. Thus, the range of drainwater volumes formed by these limits is correlated with conditions falling between existing and best available on-farm technology.

#### 3.5.2.3 Drainwater Quality

The Northern SLU Districts have been draining for many years, so the approach used to estimate WWD drainage quality is not appropriate. Historical and recent drainage operations for these Districts were described in Section 2.6 of this Report. Recent data from the Grasslands Bypass Project monitoring program indicate that the weighted average quality of discharged drain water during the period 1998-99 was 3,930 mg. per liter salinity, 0.096 mg. per liter selenium, and 7.7 mg. per liter boron. These data include only the four Northern SLU Districts - other lands draining to the Grasslands Bypass are excluded.

By 1998, virtually all of the drainage in the Bypass was as collected subsurface drain water. Therefore, the estimates above were used for the assumed starting conditions of subsurface drain water quality from the Northern SLU Districts.

## 3.6 Results

Table 3-2 presents a summary of the results of the updated analysis, covering a 50-year period (expressed in relative terms). Complete results are included as Appendix A-4. Initial salinity estimates of the subsurface drainage are based on recent data collected from the area. Drainwater volumes are based on applying the range of drainage rates (0.3 to 0.5 acre-foot per acre) to the existing drained area within the four Northern SLU Districts. For the 35,600 acres drained, the annual volume of subsurface drainwater would range from 10,680 to 17,800 acre-feet. For these initial estimates, it was assumed that surface tailwater could be captured and reused, and would not add to the total drainage volume.

For these initial estimates, it was assumed that salt mass loads would be the same for both drainage rates. As a result, drainwater salinity reaches an equilibrium value of 3,600 ppm TDS for the lower drainage rate, and reaches a proportionately reduced concentration of 2,160 ppm TDS for the higher rate. Selenium and boron concentrations are assumed to change in proportion from their starting concentrations.

**TABLE 3-2**
Total Projected Drained Area, Mass Loads, Volumes and Concentrations in the San Luis Unit

| | | | Salt | Selenium | Drainage Rate = 0.3 ac-ft/ac | | | Drainage Rate = 0.5 ac-ft/ac | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | Drained Area (acres) | Unit Mass Load (tons/ac) | Total Mass Load (tons) | Total Mass Load (tons) | Drainwater Volume (ac-ft) | Drainwater Salinity (mg/l, TDS) | Drainwater Se Conc. (mg/l) | Drainwater Volume (ac-ft) | Drainwater Salinity (mg/l, TDS) | Drainwater Se Conc. (mg/l) |
| **Westlands Water District** | | | | | | | | | | |
| 1 | 6,328 | 6.11 | 38,639 | 0.5 | 1,898 | 15,000 | 0.20 | 3,164 | 9,000 | 0.12 |
| 10 | 122,470 | 2.05 | 251,634 | 3.4 | 36,741 | 5,047 | 0.07 | 61,235 | 3,028 | 0.04 |
| 20 | 173,727 | 1.43 | 248,395 | 3.3 | 52,118 | 3,512 | 0.05 | 86,863 | 2,107 | 0.03 |
| 30 | 219,356 | 1.38 | 301,930 | 4.0 | 65,807 | 3,381 | 0.05 | 109,678 | 2,029 | 0.03 |
| 40 | 225,000 | 1.47 | 329,632 | 4.4 | 67,500 | 3,599 | 0.05 | 112,500 | 2,159 | 0.03 |
| 50 | 225,000 | 1.47 | 329,719 | 4.4 | 67,500 | 3,600 | 0.05 | 112,500 | 2,160 | 0.03 |
| **Northern SLU Districts** | | | | | | | | | | |
| 1 | 35,600 | 2.67 | 94,909 | 2.3 | 10,680 | 6,549 | 0.16 | 17,800 | 3,929 | 0.10 |
| 10 | 35,600 | 1.81 | 64,604 | 1.6 | 10,680 | 4,458 | 0.11 | 17,800 | 2,675 | 0.07 |
| 20 | 35,600 | 1.47 | 52,174 | 1.3 | 10,680 | 3,600 | 0.09 | 17,800 | 2,160 | 0.05 |
| 30 | 35,600 | 1.47 | 52,174 | 1.3 | 10,680 | 3,600 | 0.09 | 17,800 | 2,160 | 0.05 |
| 40 | 35,600 | 1.47 | 52,174 | 1.3 | 10,680 | 3,600 | 0.09 | 17,800 | 2,160 | 0.05 |
| 50 | 35,600 | 1.47 | 52,174 | 1.3 | 10,680 | 3,600 | 0.09 | 17,800 | 2,160 | 0.05 |
| **Total SLU at Build-out** | | | | | | | | | | |
| 50 | 260,600 | 2.93 | 381,893 | 5.67 | 78,180 | 3,600 | 0.05 | 130,300 | 2,160 | 0.03 |